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ABSTRACT

The study attempted to show that the first grade child's learning in a new area must involve overt concrete experiences from which new ideas will be derived. Forty-nine students, assigned to six groups, were instructed on three scientific concepts. The verbal instruction technique was similar to that suggested in SCIS. The application segment involved actual manipulation of props and simple drawings. All tests were of the interview type modeled after Piaget's revised clinical techniques. General conclusions drawn include that while the first grader's science instruction must not be limited to pictures and reading, instruction must not be exclusively involved with actual manipulations of objects either. Diagnostic placement of a child into an instructional sequence with an appropriate ratio of manipulations/representations can be based on that child's cognitive structure in that area. (EB)

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The differential effects of concrete props and graphics in instructional material for first grade children of varying cognitive structures.

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Introduction

The child whose concepts are in a preoperational stage of development in a certain area can use language to represent objects and experiences. The child's learning will progress through direct manipulation of objects coupled with verbal and nonverbal representations of those objects and manipulations. With increasing experience in that same area the child may pass into a concrete-operational stage and become able to manipulate and relate ideas in that area internally without overt manipulations of objects represented by those ideas. However, these concrete operations do depend on recently prior concrete-empirical experiences with those objects.

For the first grade child, learning in a new area must involve overt concrete experiences from which the new ideas (abstractions) will be derived. Extensions and associations of those abstractions will be made in reference to those previous concrete experiences. In designing instructional materials two problems are 1) to determine the appropriate type of overt concrete experience in the initial instruction and 2) to determine the appropriate methods to refer to those concrete experiences in subsequent instruction.

A paper presented at the annual meeting of the National Association for Research in Science Teaching. Detroit, Michigan, March, 1973

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Questions Posed

1. What differences in concept mastery result from the use of pictures or manipulative props as overt concrete experiences in an initial instructional sequence?
2. What is the relationship between a child's cognitive structure in a conceptual area and the effectivness of pictures vs manipulative props in subsequent instruction in that area?
3. If pictures and manipulative props are equally effective in a certain instance, what other factors will influence which instructional tool to employ?

Proceedure

Forth nine first grade children were stratified according to their reading ability and randomly assigned to six groups. The three concepts in which the children would receive instruction were 1) the amount of electric energy from a battery is directly related to the amount of light energy observed from the bulb, 2) the amount of movement (kinetic) energy of a ball is directly related to the change that ball can cause in an object which it strikes, and 3) the amount of movement energy in a hand generator is directly related to the amount of light energy observed from its bulb. Figure 1 shows the treatments given to each group.

In the first unit, the instruction segment (similar to the invention step in Science Curriculum Improvement Study, SCIS) involved either 1) a verbal explanation of the idea that electric energy comes from a battery and changes to light energy in a bulb and the amount of electric energy is directly related to the amount of light energy observed or 2) that same verbal

explanation accompanied by simple drawings. The application segment (similar to the discovery step in SCIS) involved either 1) actual manipulation of batteries of different "stengths" and a battery tester, or 2) simple drawings of those batteries being tested. This same format was followed for the second unit of instruction dealing with kenetic energy.

All tests were of the interview type modeled after Piaget's revised clinical technique. The first two units of instruction occurred in the same session and were followed two weeks later by third unit which dealt with kinetic energy and light energy in a hand generator. In that unit the children were given a reminder of the previous units. This reminder took the form of either 1) manipulations of the actual props used in previous units or 2) simple drawings of those props. After the reminder, the children operated the hand generator and the verbal instruction only identified an instance of light energy and movement energy. The interview test which followed asked the children to explain the factor which was responsible for the degree of brightness of the bulb. Figure 2 shows the treatments each group received. Each of the original 6 groups was divided (randomly) in half and each half received one of the two treatments in this third unit.

Results

Figures 3, 4, and 5 show the degree of concept attainment of each of the four groups or their subdivisions in each of the three concept areas.

The control groups in Figure 3 showed some concept mastery but their pre and post test scores were lower than all other groups. The control groups in Figure 4 showed much less concept attainment

than they had in the first unit. In Figure 5 the control groups again showed very low mastery.

Conclusions:

Figure 3

a. The relative high scores of the control group on pre and post test indicates that these children entered into this instructional unit with a noticable amount of mastery.

b. All instructional groups showed substantially higher scores than the control groups but the instruction and application experience treatments resulted in similar concept attainment.

Figure 4

a. The relatively low scores of the control group on pre and post tests indicates that these children entered into this instructional area with a relatively low degree of mastery.

b. The instructional groups which manipulated actual objects in their application experiences showed substantially higher mastery than the other groups. Group 3 made a better showing than group4. There seems to be an analysis of variance type interaction between the type of instruction and the type of application experience. Although there is nonparallelism, no striking interaction (crossing of lines) is shown.

c. The bigger differences between treatment groups shown in Figure 4 as compared to those shown in Figure 3 may be the result of the different amounts of inference which the children made about the drawings in those two instructional areas. In the "electric energy to light energy" instruction a primary factor was the light coming from the bulb. This was easily shown in the drawings. During the pre test the control group children were asked to describe the pictures and their descriptions indicated that they perceived that the drawings showed bulbs with different amounts of light. However, in the "kinetic energy" instruction a primary factor was the movement of the ball and its impact on the obstacle. This factor was not as manifest to the children in the before-after drawings used in that instruction. The children were required to infer motion and change from those drawings.

Figure 5

a. Group I, showing highest concept attainment in the previous units of instruction, showed highest mastery of the "kinetic energy to light energy" concepts. The two types of reminders had similar influences on Group 1.

b. The reminder involving actual manipulation of objects was superior to the reminder involving only pictorial representations of those objects for groups 3 and 4. There seems to be an interaction between the degree of concept attainment and the type of reminder used. For the child with more knowledge, a picture may work as well as an actual manipulation in some instances.

General Conclusions

a. Concepts dealing with energy are within the grasp of these young children. Because this area of energy is so important to our society these concepts should be dealt with more often in the primary school science curriculum.

b. While the young child's science instruction must not be limited to pictures and reading, that instruction must not be exclusively invelved with actual manipulations of objects either. Diagnostic placement of a child into an instructional sequence with an appropriate ratio of manipulations/representations can be based on a determination of that child's cognitive structure in that area.

c. Figure 6 speculates the cost effectiveness of various types of instruction for children of varying cognitive structures. Cost effectiveness is calculated as:

$$\frac{\text{(cost of curriculum materials)} + \text{(time and energy to impliment material)}}{\text{Concept Mastery}}$$

For some concepts, graphics may serve the same purpose as more elaborate materials for children with a higher degree of cognitive (concept) development in that area. These graphics would then have a low cost effectivness. But for children with a less developed cognitive structure graphics would be inferior to manipulative props. While the cost of those graphics would be much less than the other materials, their cost effectivness would be very high for those children. The same would be true, but in reverse order, for the cost effectivness of manipulative props.

Figure 1: Instructional treatments in unit 1 for the six groups

Instruction Unit 1: Electric Energy to Light Energy

Groups	Electric Energy Pre Test	Instruction		Application Experience		Post Test
		Verbal	Verbal + Pictorial	Testing of Batteries	Pictures of Testing Batteries	
C1 s=7	x			x		x
C2 s=8	x				x	x
I s=8			x	x		x
II s=8		x		x		x
III s=8			x		x	x
IV s=8		x			x	x

Figure 2: Instructional treatments in unit 3 for the six groups

Instruction Unit 3: Kinetic Energy to Light Energy

Groups	Reminder		Pre Test	Manipulation of Hand Generator	Post Test
	Manipulation of actual objects	Pictorial representations of objects			
C1 s=4	x		x	x	x
s=3		x	x	x	x
C2 s=4	x		x	x	x
s=4		x	x	x	x
I s=4	x			x	x
s=4		x		x	x
II s=4	x			x	x
s=4		x		x	x
III s=4	x.			x	x
s=4		x		x	x
IV s=4	x			x	x
s=4		x		x	x

Figure 3. Concept attainment in unit 1 by children receiving different instruction and application treatments.

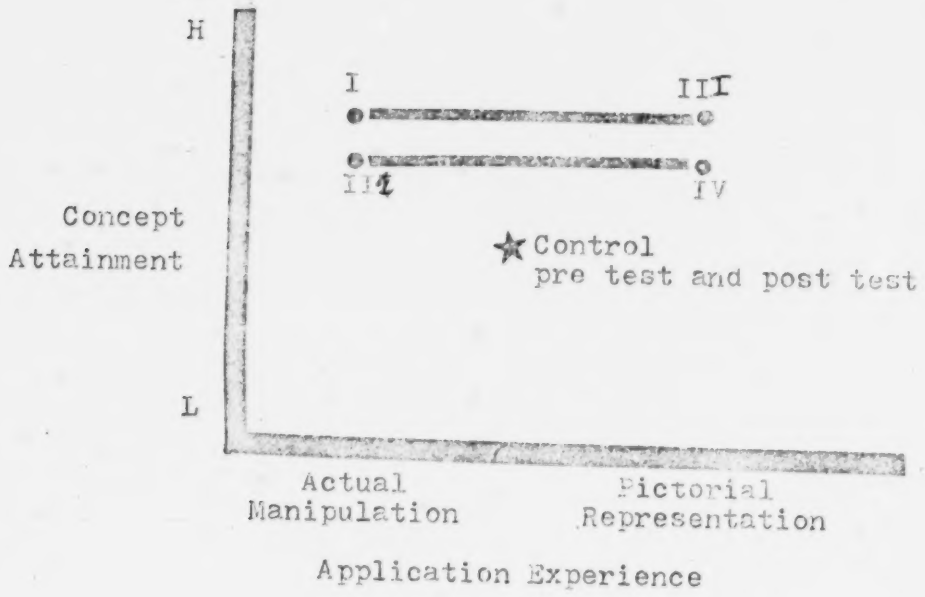

Figure 4. Concept attainment in unit 2 by children receiving different instruction and application treatments.

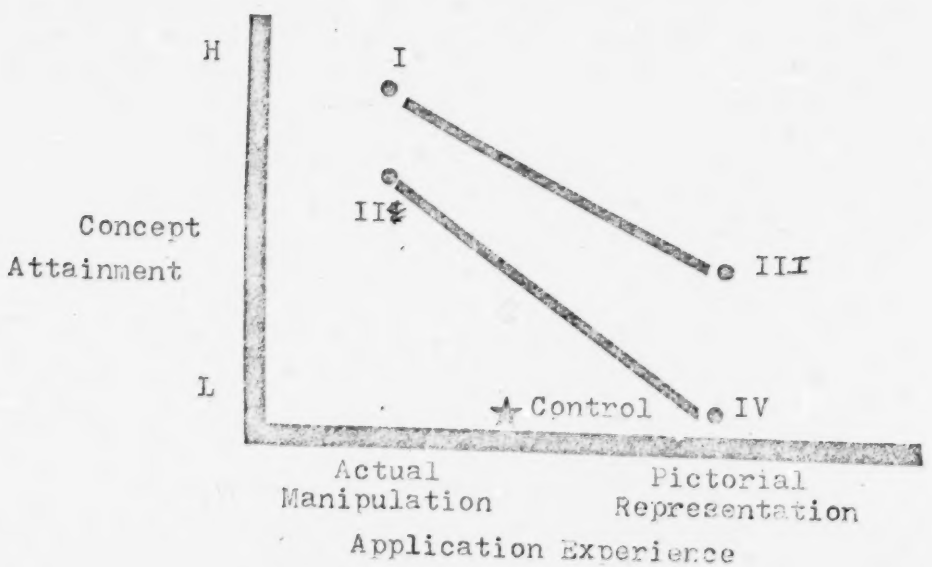

Figure 5. Concept attainment in unit 3 by children receiving different reminder treatments.

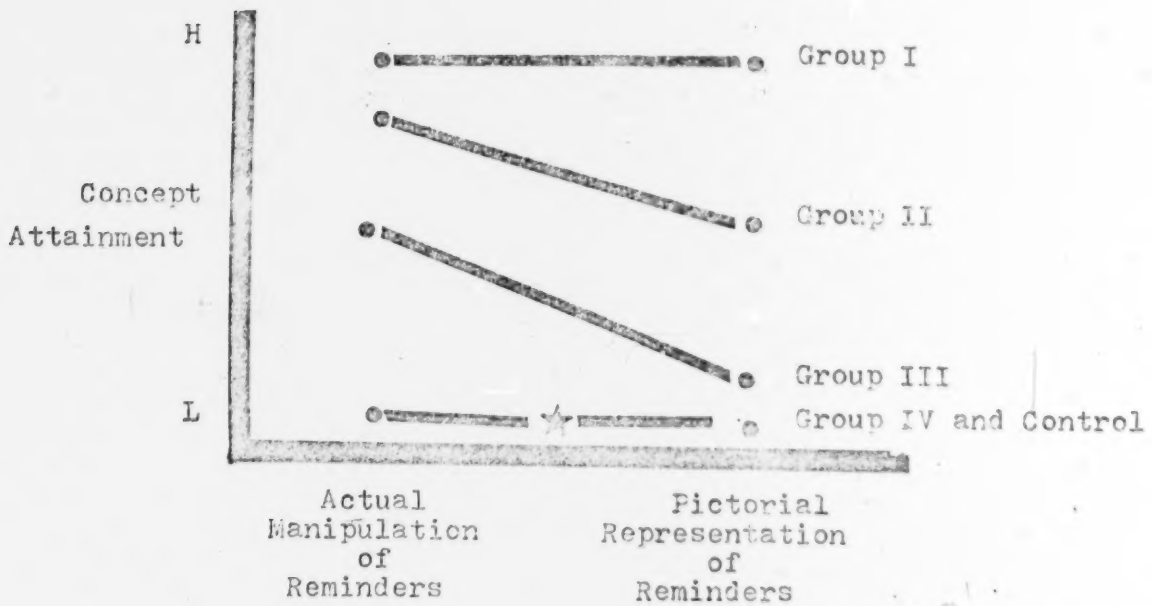

Figure 6. Cost effectivness of manipulative props and graphics for learners with various degrees of cognitive structure in the area in which these instructional materials would be used.